XLV.—*Notes on the Remains of some Reptiles and Fishes from the Shales of the Northumberland Coal-field.* By Albany Hancock, F.L.S., and Thomas Atthey.

[Continued from p. 278.]

[Plates XIV., XV., XVI.]

Rhizodus Hibberti, sp., Agassiz.

The teeth of this species have not yet been found in the shales of our neighbourhood; but large scales which appear to belong to it are not by any means uncommon at Newsham and Cramlington. They are rarely found perfect; sufficient examples have, however, been obtained to enable us to identify them with the scales of *Rhizodus Hibberti* described by Dr. Young in vol. xxii. p. 599 of the 'Journal of the Geological Society.' The largest we have seen measures three inches in diameter; they usually appear quite thin, and are of an irregularly rounded form with the front margin a little flattened, the posterior a little produced, and the sides only slightly arched. The surface is marked with numerous sharp concentric lines of growth and minute, close, radiating striæ, requiring a good lens to show them. There are also a few distant delicate ridges, extending from the centre to the anterior border.

Such scales are undoubtedly in an imperfect condition. When complete, they are considerably thicker, and the under surface has a smooth bony appearance, exhibiting nevertheless decided concentric lines of growth, a subcentral elongated boss, and numerous small pits, particularly on the posterior portion, which, however, we have never seen in a good condition. On the posterior or exposed area there are a few obscure, irregular, radiating ridges, which are rendered still more indistinct by the granular tubercles that are scattered over the surface. The smaller scales, which are usually about one inch and three-quarters long and scarcely one and a half inch wide, have all the characters of the large scales; but they are generally more elongated in form, and the minute radiating striæ are coarser.

Besides these scales, several bones have occurred at Newsham, which, from the peculiar surface-sculpture, most probably also belong to this powerful fish. We were anxious to prove this by comparing them with some authenticated fragment of the bone of *Rhizodus* showing the surface-ornament, but have failed in our endeavour. They agree, however, in this respect so well with the descriptions, that we cannot hesitate to assign them provisionally to this species.

Of the two most remarkable bones of this collection, one

approaches in form to the malar of the Alligator, and reminds one somewhat of the bone in *Asterolepis* considered by Agassiz to be a premaxillary*; but in our specimen the articular portion is wanting. The other bone is apparently the posterior part of a mandibular ramus with a wide articular process at the hindermost part, not perfect though very distinctly displayed. The former of these bones is quite four and a half inches long, and upwards of one inch wide at the broadest part; it is thin in front, thickens backwards, and bends rather abruptly down at the posterior extremity, which is broken. Along the under margin there is a wide, flat, thin, squamous process, probably for the articulation of the maxilla; the opposite margin is not perfect; but in a smaller specimen of the same bone a similar flat articular process extends from the upper margin also.

The bone which we suppose to be the posterior portion of a mandibular ramus is nearly five inches in length and one and a half inch wide, including the lateral squamous expansions; it is thin, flat, and rounded in front; behind it is much thicker; and though the posterior extremity is wanting, the greater portion of the articular process is present; it has a wide oblique glenoidal surface. The lateral squamous expansions will undoubtedly articulate with the dentigerous bone.

Other interesting bones have also occurred, some of which can be identified as jugulars. One distorted and folded mass comprises two large jugulars, apparently the pair of principal plates. A considerable portion of one of them is well displayed, exhibiting in very good condition the surface-ornament. Were this plate unfolded, it would be about seven inches long and two and a half inches wide. Three or four inches of what seems to be the posterior portion lies flat upon the matrix, and shows the contour quite perfectly. The plate is apparently equally thin throughout; and the outer margin seems, judging from the portion that is displayed, to be pretty regularly arched, and the posterior margin to be rounded and sloped a little forwards towards the inner border.

Another bone, probably also a jugular, is worthy of notice. This appears to be an anterior plate; nearly one-half of it can be made out: it is symmetrical, having a stout angular midrib with two lateral wing-like expansions. When entire, it would be four and a half inches wide and one inch and three-quarters long. It is impossible to overlook the resemblance of this bone to the jugular plate of *Asterolepis*; and, like it, this probably fitted into the top of the arch formed by the junction of

* Poissons Fossiles du Vieux Grès Rouge, troisième livraison, p. 95, tab. 32. figs. 18, 19.

the mandibular rami. In *Rhizodus*, however, there appear to be two other plates, as we have already seen: these would lie, one on each side of the median line, immediately behind the anterior plate, which is very nearly as wide as the two others put together.

All these bones, as well as several other fragmentary specimens, have the surface covered more or less densely with strong vermicular sculpture composed of hollows and ridges; the latter in some become tubercular, but in others stream over the surface smoothly and regularly, with here and there an occasional bifurcation; in others, again, the vermicular grooves are intricately involved, and sometimes they are broken up to form circular pits. These are the dominant markings in the bones already before us; but the sculpturing on the surface of some opercular plates which we also assign to the same large fish, and which will presently be described, is somewhat modified. In these the vermicular ornament is less developed, and the pitted and tubercular predominate, the ridges being rough and much broken up.

It is on account of these peculiar surface-characters that we deem these bones to belong to *Rhizodus*; but this is not the only evidence. On the slab with the anterior jugular plate there is a portion of a scale of *Rhizodus*; and on that with the two large jugulars several scales of this fish are found lying in contact with them. If we are right in attributing these scales to *Rhizodus*, we have in the above facts strong corroborative evidence that these bones also belong to it.

The opercular plates above referred to are four in number: three are opercles, one is apparently a præoperculum. They are all crescentic in form, having their anterior margins well hollowed, and both extremities considerably produced. The largest operculum is six inches from point to point, and is upwards of two and a half inches wide; the posterior margin is a little sinuous, and is bordered with several parallel depressed lines, probably indicative of growth; the anterior margin is bounded by a wide, smooth, articular surface, which is divided from the rest of the operculum by a ridge. The præoperculum is similar in form to the operculum, but it is wider in proportion to its length, and there is a single groove following the sinuosities of the posterior border; the anterior margin is concave, with a very narrow articular surface.

Note.—It is the intention in this and the following notes to comment on the value of the various genera and species recently proposed by Prof. Owen in his paper "On the Dental Characters of Genera and Species, chiefly of Fishes, from the

Low-Main Seam and Shales of Coal, Northumberland"*. It has become necessary to do this, as the anticipated beneficial results from the former "Criticism" of the "Abstract" of the paper as read have not been realized†, though the influence of this criticism is distinctly traceable in the text of the published paper, as well as in the appended footnotes.

The first genus we have to refer to is that named *Mioganodus* (pl. 8), which is founded on the section of a tooth that in no respect differs from that of the so-called *Rhizodus lanceiformis*, Newberry. We have shown in the former part of this communication that this reputed fish is most probably a Labyrinthodont amphibian; but be this as it may, we have teeth of this species attached to the dentary bone exactly similar in contour to, and not larger than, the figure of the tooth of this so-called new genus: and when a longitudinal section of these teeth is examined under the microscope, there is no perceptible difference in the minute structure from that of the tooth of *Mioganodus*; even the concentric layers of dentine, which are considered characteristic, are equally well marked. Certainly, when the tooth of *R. lanceiformis* is perfect, the base exhibits the Labyrinthodont infolding of the peripheral wall of dentine; but when the tooth is found detached (and that figured by Prof. Owen was so found), the basal portion is rarely if ever present; and then the dentinal walls are observed to thin out from the interior and to terminate below, when seen in section, in sharp wedge-shaped points, just as they are represented in the figure of *Mioganodus laniarius*. The tooth, then, on which this genus is founded is merely the upper portion or crown of a tooth of the so-called *Rhizodus lanceiformis*.

Rhizodopsis sauroides, sp., Williamson.

Several specimens of the elegant fish upon which Professor Huxley founds the genus *Rhizodopsis*‡ have occurred at Newsham. They are all in a very incomplete state, though, with the aid of the whole series, many of the characters can be determined. The most perfect specimens are between five and six inches in length; the largest is eight inches long, exclusive of the tail, which is wanting; and the smallest is not more than two or three inches in extent. There is proof, however, that this species sometimes attains a considerable size: a crushed head has been found that measures nearly three and a half inches in length; and ossified vertebral rings have occurred that are nine-tenths of an inch in diameter.

* Trans. Odontological Society, 1867.

† Geological Magazine, vol. iv. pp. 323 & 378.

‡ Quart. Journ. Geol. Soc. vol. xxii. p. 596 (1866).

In all respects our specimens agree well with Dr. Young's description of this species in the 'Journ. Geol. Soc.' (*loc. cit.*). The scales are usually well preserved; all the fins, as well as the tail, can be determined; and the gill-opercles, mandibles, and upper jaws, in a more or less entire state, with the teeth attached, are all displayed.

The scales vary, of course, greatly in size; on the smallest fish they cannot be more than a quarter of an inch long, while large detached scales measure an inch in length. They are all, however, so perfectly similar that it is impossible to deny their specific identity. The coarseness of the surface-sculpture and the thickness of the scale vary, as might be expected, with its size; but no other difference can be detected. It is therefore only left us to follow the prudent caution of Dr. Young, and to wait for further information before doing anything so rash as to divide specifically the thin and delicate from the thick and comparatively coarse scales. There is one character, however, which seems to have escaped the notice of this palæontologist, and which is pretty distinct in one or two of our examples. The dorsal and ventral fins are protected in front by a series of thick enamelled scales, which are brilliantly glossy and minutely punctured, not at all like the body-scales, but similar to those in front of the fins, in *Megalichthys*. The first or proximal scale is very stout, if not a solid cylinder, and is three-quarters of an inch long; it looks almost like the base of a spine, but is probably composed of two lateral plates. This is succeeded by a double longitudinal series of elongated rectangular pieces, which extend apparently almost to the distal margin of the fin.

The premaxillary bones, which were wanting in Dr. Young's specimens, are present in some of ours; and they, as well as the mandibles, have a large, slightly curved laniary tooth at the distal extremity. This is succeeded by a series of numerous small conical teeth, of the same size and character as those of the maxilla. These, as well as the small mandibular teeth, are placed at pretty regular intervals, though it is not uncommon to observe two or three pressed close together. Traces of two or three additional laniary teeth can be observed in the mandibles, situated on a line a little within the row of smaller teeth.

The premaxillary bone is unusually long; the maxilla is shorter than the former, and is narrow in front and expanded considerably behind. The mandibles are long, narrow bones, with the margins nearly parallel and the distal extremity rounded. The surface of all these bones is rugose, with irregular reticulated ridges or wrinkles and punctures.

All the bones of the jaws frequently occur detached. A large series of such have been procured, many of which are associated with the scales of the fish. The anterior laniary teeth are nearly always present in both the præmaxillæ and mandibles; but the additional large teeth of the latter are seldom present. In four or five instances, however, they are distinctly displayed; and in one specimen there are five laniary teeth, including the anterior one.

In the detached state the form of these bones can be well observed. The maxillaries are usually seven-tenths of an inch long and about three-tenths of an inch wide at the broadest part. They are flat thin bones, produced and pointed in front, and widened rather suddenly behind, as already stated; the alveolar border is nearly straight; the upper border in front is parallel with the alveolar border for some little distance backwards; it then suddenly ascends to the posterior margin, which slopes backwards and downwards. There is, at a little distance from the anterior extremity, a well-developed narrow articular process, which stretches upwards and forwards. The teeth vary somewhat in number; there are usually about twenty-five, which are arranged along the alveolar margin in regular order. This regularity, however, is frequently disturbed by the approximation of two or more; sometimes three or four are placed close together.

The premaxillaries are long narrow bones, about as long as the maxillaries, being usually seven-tenths of an inch in length and nearly three-tenths of an inch broad; the alveolar margin is almost straight; the opposite margin gently slopes backwards in a somewhat sinuous course; so that the bone is pretty regularly wedge-shaped, the posterior extremity being pointed. There are about the same number of teeth as in the maxilla, with the addition of a large conical laniary tooth in front, immediately before which is a small tooth or two.

The mandibular bone we have never seen quite perfect: one of the most complete in the series measures one inch and four-tenths in length, and about two-tenths of an inch wide near the front; the upper and lower margins are nearly parallel; it is rounded in front, and appears to taper a little at the posterior extremity; the anterior extremity is slightly bent upwards. There are from fifteen to twenty teeth in our fragments; the number must be much greater in the entire ramus. There is likewise a large laniary tooth in front, and three or four others placed along the ramus, in a line within the small teeth; in front of the anterior laniary there is a small tooth or two like those in the præmaxilla. These, however, are not always to be seen; and the posterior laniary teeth are very

rarely present, or are perhaps frequently buried in the matrix. They are placed at some little distance from each other; and the small external teeth, like those of the upper jaw, frequently exhibit considerable irregularity, though on the whole they are placed apart at pretty regular intervals. The above description of the jaws applies to those of the usual size; but we have a mandibular bone which, if complete, would be upwards of three inches long, and a maxillary or two of corresponding dimensions.

The laniary teeth are grooved at the base; and here the peripheral dentine is a little infolded or plicated; and in fine specimens the surface of the crown exhibits a thin film of enamel. Traces of enamel, too, are occasionally found on the small teeth; but they are most frequently without it, probably in consequence of erosion.

One curious fact in connexion with the occurrence of this species is worth recording. Several of our specimens were found concealed within the stems of reed-like plants, which bear somewhat the appearance of calamites. A single individual occurred in each stem, nearly filling it. How they got into this position, whether accidentally or otherwise, it is impossible to form an opinion; but as, out of a score of individuals that have been found, four or five have been so placed, it would seem that something more than mere chance has had to do with it.

Note.—It is apparently on fragments of the jaw-bones and on the teeth of *Rhizodopsis sauroides* that Prof. Owen has founded his *Dittodus parallelus*, *Ganolodus Craggesii*, *Characodus confertus*, and the Batrachian genus *Gastrodus*. The figure of *Dittodus parallelus* (pl. 1) seems to us to represent nothing more than a fragment of either a mandible or maxilla of this fish, with a few pairs of the teeth in juxtaposition, the rest having been removed either before deposition or in making the section.

When two teeth grow up close together, as we have seen is not unfrequently the case in this species, the peripheral dentine of the two is often united at the base, and then we have a "twin-tooth" in all respects similar to those figured of this so-called *Dittodus*, and just as well entitled to be compared to the "Siamese twins." We have now before us numerous sections, many of which were made several years ago, demonstrating this fact; and in one or two instances there are even three or four teeth so united.

That which is denominated "osteo-dentine," in the apical part of the pulp-cavity, is, we apprehend, a mere film of the

inner layer of dentine. A similar substance occurs in many of our sections, exhibiting the general appearance and dotted structure given to it in Prof. Owen's figure; and this is undoubtedly the inner film of dentine; and the dots are the orifices of the calcigerous tubules. When the film is a little thicker, the dots become elongated; and in other specimens they gradually assume the regular tubular appearance, in accordance with the increased thickness of the section.

Ganolodus Craggesii is founded on a mandibular bone of the same fish. This fragment is a little distorted, and has the posterior extremity broken off and turned forwards; and all the laniary teeth, with the exception of the anterior one, are lost, as we have already seen is frequently the case in the mandibles of *Rhizodopsis*. The size, form, and surface-sculpture of the bone, which latter is well represented in the wood-cut, as well as the character, size, and arrangement of the teeth, all prove this.

There is no difference whatever between this mandibular ramus and several that are now before us of *Rhizodopsis*. *Ganolodus Craggesii*, Owen, will therefore have to give place to *Rhizodopsis sauroides*, sp., Williamson.

Ganolodus sicula (pl. 7) is very intimately related to a very different fish. The tooth on which this species is sought to be established is perhaps the commonest in the shales of the Low-Main seam; it belongs to *Megalichthys*, and is apparently a laniary tooth of a young specimen. There is not the slightest perceptible difference in the form and structure of the tooth, as represented in the figure of this so-called species, and the form and structure of the numerous sections of teeth of *Megalichthys* which we happen to possess. That the specimen figured was grooved and plicated at the base, like the tooth of this fish, is proved by the remnants of the plicæ, as may be seen on referring to fig. 1 *b*, pl. 7. Prof. Owen calls these fragments "part of the parietal dentine." Were this strictly correct, the calcigerous tubules would be seen cut across, producing the appearance of dots more or less elongated, as is well represented by Mr. T. West in pl. 14. fig. 4 (*Gastrodus*). On the contrary, the tubules in the fragments alluded to are all exhibited lengthwise, as they are in the cut edge of the peripheral dentine—proving to demonstration that these fragments are portions of the basal plicæ. To be satisfied of this, it is only necessary to examine a longitudinal section of the tooth of *Megalichthys* or any other tooth with a plicated base.

The variety *G. undatus* (pl. 7. fig. 7) is most assuredly the tooth of *Strepsodus sauroides*, Huxley: the double bend of the apex and general proportions of the crown put this beyond doubt.

A fragment of a maxillary bone of *Rhizodopsis* has, it is impossible to doubt, served for the establishment of the so-called *Characodus* (pl. 13). Here there is not one tooth left; they are all broken away; but the form of the fragment itself, tapering at one extremity and suddenly expanding at the other, as likewise the columnar structure of the bone for the support of the teeth, prove this to be an imperfect maxillary of *Rhizodopsis sauroides*. These peculiar pillars of bone supporting the teeth are very characteristic of the jaw-bones of this fish; but in the præmaxilla they are most developed. Some of our specimens (Pl. XVI. fig. 5) are precisely similar to that figured as *Characodus*, the teeth having been all broken away, with the exception of three or four. The display of this curious structure depends much on the plane of the sections; it is possible to cut it nearly all away, leaving merely the external layer of bone on one side; and it is never developed to the same extent in the præmaxilla and mandible.

The præmaxilla is the basis of the genus *Gastrodus* (pls. 14 & 15) the supposed Batrachian, as is evinced by the shape of the fragment, the size, form, character, and disposition of the teeth; nor is there any important difference in the minute structure of the teeth in this so-called genus. According to Prof. Owen's measurements, the dentinal tubules in *Dittodus parallelus* have a diameter of $\frac{1}{10000}$ of an inch, in *Characodus* $\frac{1}{12000}$ of an inch, and in *Gastrodus* $\frac{1}{10000}$; while in *Rhizodopsis* we have ascertained that they are likewise about $\frac{1}{10000}$ of an inch in diameter. The teeth of the so-called *Gastrodus* are certainly represented to be without enamel; but we have seen that it is frequently absent in *Rhizodopsis*; and many of the teeth, as exhibited in the figure, are cut diagonally short, so that their form and proportions are destroyed. The appearance thus presented is very common in sections of minute jaws, and, unless clearly understood, may readily lead to error. The diagonal section of a quill illustrates this very well.

The bone-cells of the jaw of *Rhizodopsis* are quite as Batrachian as are those figured of the pseudo-*Gastrodus*; and so are those of *Megalichthys* and many other sauroidal fishes.

There is, then, no evidence in the paper referred to of a minute air-breathing Batrachian of the age of the lower seams of the Northumberland coal-field, the so-called genus *Gastrodus* being resolvable into *Rhizodopsis sauroides*, a Ganoid fish.

Ctenodus cristatus.

Since the publication of the paper on *Ctenodus**, the matrix

* Ann. & Mag. Nat. Hist. Feb. 1868.

has been carefully removed from the upperside of the large sphenoid bone of this species by which the size of the fish was estimated. And now this interesting specimen reveals to us the cranial bones of the occipital region in an undisturbed and excellent state of preservation. The whole of the bones of one side are almost perfect; so that there is no difficulty in restoring this portion of the cranium, the constituent bones of which are arranged exactly as they are in the figure of the "cranial buckler" of *Dipterus* given by Hugh Miller in his 'Footprints of the Creator.'

The bones vary little in size, and, with the exception of the central occipital and parietals, are mostly irregularly pentagonal. There are three occipitals: the central one is not much larger than the lateral; the former is nearly as wide as it is long, and is seven-sided, with the anterior margin a little pointed in the centre, and the posterior margin nearly straight. The lateral occipitals are connected with the postero-lateral margins of the central occipital, and, diverging in front, admit a bone on each side, which is wedged in between them and the antero-lateral borders of the central occipital and the external margins of the parietals. External to these bones, and in connexion with their outer margins, are three other bones, which form the lateral borders of the cranium. In all there are five bones on each side of the central occipital and posterior part of the parietals. Only a small portion of the left parietal is preserved; but enough is present to show that this pair of bones are elongated, being widest apparently a little behind their centre, and having their posterior margins slightly divergent to receive the anterior angle of the central occipital.

The surface of the bones is not ornamented with "waved and bent lines," as those of *Dipterus* are described to be by Miller (*ibid.* p. 61), but is minutely granulated and punctate, similar to that of the opercles described in the paper on *Ctenodus* already referred to, and here and there are indications of the radial bone-structure beneath.

The original estimate of the width of this head was nine inches. It is now evident that it really was eight and a half inches across the occipital region, without taking into account a fragmentary bone, probably a portion of an operculum. Were this added to the above measurement, the width would be ten inches.

The external characters of the palatal plates of the various species of *Ctenodus* were described in the paper on that genus mentioned above. Nothing, however, was said of the internal structure, such matters of detail having been reserved for some future occasion. But it is now perhaps desirable to give some

account of the microscopical characters of these peculiar dental plates.

In sections made across the transverse ridges that cover the whole surface of the plates, a very beautiful structure is presented to view. The entire substance is found to be composed of a minute reticulation of bone-like matter, the meshes or medullary canals being large and much complicated. The ridges stand up from the surface in the form of conical tooth-like processes; and the reticulated matter of which they are composed is perfectly continuous with that of the plate or base; but the meshes or medullary canals in them are a little elongated, and the surface is protected by a compact, rather thin layer, which is only distinguishable from the rest of the tissue by its density and darkness of colour; on this layer there is a thin external coating of enamel.

At the base of the plate there is a stratum of considerable thickness in which the reticulation becomes somewhat closer, and which is characterized by numerous short elliptical bone-cells, the radiating canaliculi of which are frequently obliterated, but in well-preserved specimens they can be observed distinctly. The network of this stratum is continuous with that which lies immediately above it, but is at once distinguishable by its darker colour, greater density, and the presence of radiating cells. The substance forming the reticulation of the upper portion of the plate is, on the contrary, devoid of bone-cells, and is pale and transparent; but it is coated with a thin layer of a darker matter, in which are numerous branched tubules. When the section is made very thin, these tubules, however, all disappear, and the substance is then to all appearance perfectly homogeneous. These tubules are likewise very frequently invisible, even in comparatively thick sections, probably on account of the state of the fossil; or it may be that the canaliculi have all disappeared under the influence of the balsam used in mounting the specimens.

The peripheral enamel is very often wanting; and even the dense continuous layer of bone-like matter immediately beneath it is frequently entirely worn away; and then the section presents a rugged margin.

The microscopic structure of *Ctenodus* has been figured and described by M. Agassiz, in his 'Poissons Fossiles' (vol. iii. p. 166, tab. M. f. 3). The figure is very good, so far as it is worked out; but when the author describes the "cellules calcifères" at the base of the plate as without ramifications, it is evident he has been deceived, probably by the use of balsam; or it is just as likely that the canaliculi had not been preserved in the specimen he examined. He is also wrong in

his assertion that "la substance qui forme la surface extérieure de la dent est parfaitement homogène, sans trace de structure quelconque." If his sections had been made very thin, this substance would undoubtedly have appeared so. The examination of many specimens is frequently necessary to correct errors of this nature.

Note.—It is on the palatal tooth or plate of *Ctenodus*, probably of *Ctenodus obliquus* (or, perhaps, *C. elegans*, or it may be on a minute plate of one of the larger species) that Prof. Owen has founded his genus *Saganodus* (pl. 12). This is one of the genera on which no remark was made in the "Criticism" of the "Abstract;" but a mere glance at the figure in the paper is sufficient to satisfy us that it represents nothing else than a small imperfect palatal plate of this genus. One of the authors of the present communication has had in his cabinet for many years numerous sections of the palatal plates of *C. obliquus*; and on comparing them with the figure of the "teeth and a small portion of the jaw" of the so-called *Saganodus*, no difference of the slightest importance can be perceived. The six wedge-shaped ridges seen in transverse section stand up from the bony network of the plate in the form of conical tooth-like processes, all inclined a little to one side, and increasing in size towards the same side, and having their reticulated substance continuous with that of the plate. In all these respects the resemblance to the figure is so great that no one can doubt for a moment that the so-called jaw and teeth of *Saganodus* are identical with the palatal tooth of one of the *Ctenodi*.

In the example figured by Prof. Owen, as also in many of our specimens, the external enamel and the peripheral walls of continuous matter have been worn away. His section is evidently a little diagonal, as proved by the increased depth of the plate ("jawbone"). And the minute structure, as rendered in fig. 3, is perfectly similar to that of many of our specimens.

In the so-called *Saganodus* we see a remarkable example of the danger of trusting entirely to sections of minute objects, the planes of which are not understood. The oral armature of *Ctenodus* we have seen is composed of plates having on the surface several transverse wedge-shaped ridges, which are usually denticulated or tuberculated. Had it been understood that the specimen examined was a section cutting such ridges transversely, it never could have been described as a fragment of a "jaw supporting conical teeth."

It has been already stated that the enamel is frequently

worn away. It is, however, generally persistent towards the outer margin of the plate; a little further back it is almost invariably removed; and still further back, on the older portion of the plate, the peripheral wall of hard matter is scarcely ever found, having undoubtedly been worn down by the action of the jaws. It is therefore clear enough that, in accordance with the line of the section, we might have the margins of the tooth-like processes rough, without any distinct peripheral wall, as in the figure of the so-called teeth of *Saganodus*; or there might be such a wall, without any external enamel; or, again, both the enamel and peripheral wall might be present: and such a series of sections of *Ctenodus* we possess. Were we, then, ignorant that the sections were made from different parts of the same object, we might readily be led to erect three distinct genera on the palatal plate of a single species of *Ctenodus*. And, again, were we disposed to create species, various degrees in the obliquity of the section would afford excellent opportunities for so doing, as the tooth-like processes would vary in length and form in each section.

Palæoniscus Egertoni, Agassiz.

Two large patches of scales, representing the greater portion of the fish, have occurred at Newsham. The scales are in a very good state, and show the characteristic markings of this very pretty species; when examined with the microscope, it is perceived that the surface of enamel is regularly covered with extremely minute punctures or dots. The larger patch is one inch and five-eighths long, and upwards of three-eighths of an inch wide. The fins are not displayed; neither are there any traces of head or tail.

Several other *Palæonisci* have been found in our shales, as well as one or two species of *Amblypterus*. There is also in the collection a specimen or two of what we take to be a species of *Eurylepis*, Newberry. Though these are not in a very perfect condition, they are in a much better state of preservation than the specimens of *P. Egertoni*. In many of them the head is present; and both the tail and fins are frequently determinable. Several of them are probably new; but at present we cannot enter more fully on this branch of the subject, and must leave it for some future opportunity. A few words, however, may be said on the dentition of these fishes, particularly as it seems to be little understood; indeed it appears that little or no attention has been given to this matter.

M. Agassiz, in his great work, 'Poissons Fossiles,' states that the teeth of *Palæoniscus* are "en brosse" (tome ii. pt. 1. p. 42); but the words which immediately precede this expression

must be taken to qualify it. They are,—"Mais les dents sont si excessivement petites qu'il est très-rare de pouvoir les distinguer." From this it is pretty evident that this distinguished naturalist knew very little about the matter. Succeeding writers, however, appear to have rested satisfied with this description. Mr. Binney, indeed, so long ago as 1841* figured the jaw of *Palæoniscus Egertoni*, showing a row of large, conical, sharp-pointed teeth, as well as a few of the small external ones. He says that the jaw is "armed with sharp conical teeth of a nearly uniform size, inclining from the front." This communication, however, has been unfortunately overlooked.

The teeth of these jaws are not "en brosse," neither are they of that feeble "villiform" structure so much insisted on of late. They are disposed in two distinct rows, one within the other, much in the same fashion as in *Megalichthys* and *Rhizodopsis*, but still much more like that which obtains in *Pygopterus*, in which the teeth are likewise arranged in two rows—one being of large laniary teeth, the other of small external ones. And, according to M. Agassiz, they do not in this genus form "une brosse ou râpe comme les dents du *Polyterus*." The inner row in *Palæoniscus* (Pl. XV. figs. 3, 4, 5) is composed of a few comparatively large, curved, sharp-pointed conical teeth, which are placed at some little distance apart from each other. In the outer row the teeth are numerous, small, conical, and pointed, occasionally crowded, and in some species apparently not quite in regular order.

It is this outer row of comparatively small teeth that appears to have been seen and described by M. Agassiz, the inner row of laniary teeth having escaped his observation. Nor is it any wonder that such a matter of detail should have been overlooked by this naturalist; and, indeed, many such omissions are found in the great work alluded to. But when we consider the novelty and vastness of the matter before him, and especially that the bent of his mind was directed mainly to the larger problems of his subject, the only marvel is that such blunders are not more numerous. The laniary teeth are very frequently concealed in the matrix; and when the jaw is in its natural position, they are liable to be obscured by the external row, which stands up on an elevated ridge of the alveolar margin.

The laniary teeth vary in number in the different species, and probably, in a limited degree, even in the same species: but this is difficult to determine; for it rarely happens that the

* Trans. Manchester Geol. Soc. vol. i. p. 167, pl. 5. fig. 12 (1841).

row is complete, these large teeth being frequently broken off. Nevertheless in several of our specimens they can be observed arranged at pretty regular intervals, evincing that the series, as far as it extends, is complete. In one mandible, in which the row is nearly entire, there are eighteen or nineteen teeth; and in the mandible of another species fourteen or fifteen can be counted. The teeth in the maxillæ appear to be equally numerous.

The teeth themselves (Pl. XVI. figs. 1 & 2) are, as we have already said, sharp-pointed and conical; they are a little recurved, the bend being usually greatest a short way above the base. Fine large specimens are upwards of one-eighth of an inch long; but they are generally much less; they vary considerably in this respect in the different species. They are most frequently wide at the base, and contract rather suddenly immediately above; thence the attenuation is very gradual, until within a short distance of the apex, a little below which the crown is slightly swelled; from this point the sides of the tip incline more rapidly towards each other, and unite to form an extremely sharp apex. In some species the apex is much produced and attenuated, in others it is comparatively short; but in all it is characterized by its sharpness. The sharp-pointed tip or apex is formed of a thick cap of enamel, and is usually quite smooth and highly polished. Below the cap, in all the species examined, the crown has a subdued lustre, and is fretted in a very beautiful manner with numerous minute, short, close-set, longitudinal depressions, which, being arranged lengthwise, have occasionally a lateral inclination: hence the peculiar fretted appearance of the surface.

On making a longitudinal section (Pl. XVI. fig. 2), the pulp-cavity is seen to conform to the shape of the crown; the cavity is wide below and narrow above, tapering gradually towards the apex, and terminating just within the extremity of the dentine. The tip of enamel fits on to the top of the dentine like a ferrule, and is in the form of an inverted V, with the angle filled up for some distance, and the stout limbs turned out a little below and mortised, as it were, into the dentine. The enamel-cap varies a little in form in the different species; but it varies still more in accordance with the plane of the section. When the section is made directly through the centre, the solid apical portion of the enamel is seen to be much produced, and very sharp. By making the section a little eccentric, the solid tip is reduced in length and sharpness; and by carrying the process a little further, the enamel-cap becomes a mere thin covering, like a transverse section of

a low-pitched roof; and at last it entirely disappears, and is replaced, as it were, by a somewhat obtuse point of dentine.

In the finest specimens, the whole tooth below the enamel-cap is coated with a distinct film of enamel, which is perfectly colourless; in others traces of it are observed only here and there; but in by far the greater number it is entirely wanting: when this is the case, the surface of the tooth is frequently observed to be roughened, as if by erosion. And it may be here stated that it is not merely the enamel that is eroded, but it frequently occurs that in the teeth of *Palæoniscus*, as well as in the teeth of other small fishes, the dentine itself is worn away to such an extent that very little of it is left to protect the pulp-cavity. It is, therefore, not unlikely that all the teeth of *Palæoniscus* were originally coated with enamel; or it may be that in some species there is an external coating of enamel, and in others it is wanting. When the tooth is perfect, its walls are thick in proportion to the calibre of the pulp-cavity; the calcigerous tubes are very fine and numerous.

Note.—After the above description of the tooth of *Palæoniscus*, it is scarcely necessary to say that there is no character by which it can be distinguished from that of the so-called genus *Ganacrodus* of Professor Owen (pl. 6): the teeth of the latter and former agree in size, form, and structure. We have found the enamel-tip to exist in *P. comtus* and other species from the marl-slate as well as in the species from our Coal-measures. This we have proved in the most satisfactory manner, not by taking the teeth at random as they are scattered through the matrix, but by taking the jaws from the heads of well-authenticated *Palæonisci*, and examining the teeth both externally and in section. After having done this in a great number of specimens, we are enabled to state that the small enamel-tipped teeth found detached in the Cramlington and Newsham shales are exactly the same as those attached to the jaws. They are of the same size and form, with the same bright tip of enamel and finely fretted walls; and in section there is no difference whatever; the general form, the enamel-cap, the pulp-cavity, and dentine are all precisely the same; and all precisely agree with the tooth of the so-called *Ganacrodus*. It is therefore hard to understand what is meant by the use of such terms as "the villiform teeth of *Amblypterus* and *Palæoniscus*," "the vague and ill-defined characters of those *en brosse* of *Palæoniscus* and *Amblypterus*." Such expressions may indeed mislead, as they or similar words appear to have misled their author;

but they can never for a moment obscure the light derived from a thorough examination of the facts.

The laniary teeth of *Palæoniscus* and *Amblypterus* agree in all essential characters; and the tooth of the former is in every respect similar to that of Prof. Owen's "new genus." Consequently this genus can never be adopted by palæontologists.

With regard to the coating of enamel on the crown of the tooth, on which much stress is attempted to be laid, we can only say, in addition to what has been previously stated, that it is most frequently absent from teeth attached to the jaws, and that by far the greater number of our specimens are deprived of it, (as we are inclined to believe) from the effect of erosion. Be this, however, as it may, the fact remains unchanged. Authenticated *Palæoniscus*-teeth in connexion with the jaws agree in all respects with the tooth of *Ganacrodus*, even to the absence of enamel on the crown of the tooth.

Palæoniscus, however, is not the only genus in which this beautiful enamel-cap exists. Although Prof. Owen is pleased to ignore what is stated in the previous "Criticism" on the subject, we here venture to assert that the teeth of *Pygopterus*, *Amblypterus*, *Gyrolepis*, and *Cycloptychius* have a perfectly similar tip of enamel. This we have determined by our own independent research, and can prove the fact by numerous sections of the teeth of all these genera.

Considerable importance, however, appears to be attached to the supposed novelty of this peculiar tooth-structure in the paper so often referred to. Prof. Owen therein states, on this subject, "that he had not before met with any similar tooth in the whole range of his odontological researches" *. Between twenty and thirty years ago, however, M. Agassiz described and figured the very same structure in the teeth of *Pygopterus* †, *Saurichthys* ‡, *Polypterus*, and *Lepidosteus* §, the last two being recent sauroid fishes.

After giving a full description of the general characters of the tooth of *Pygopterus*, M. Agassiz says, "Un cône de dentine entoure cette cavité pulpaire de tous côtés; il est plus massif au milieu, là où se voit le renflement extérieur, plus mince vers la base et vers le sommet, et recouvert en haut d'un capuchon en émail, qui occupe à-peu-près le tiers de la dent et forme à lui-seul toute la pointe. En examinant

* Pamphlet reprinted from the 'Trans. of the Odontological Society,' p. 29.

† Poiss. Foss. vol. ii. pt. 2. p. 152.

‡ Ibid. vol. ii. pt. 2. p. 153, tab. H. figs. 2–5.

§ Ibid. vol. ii. pt. 2. pp. 27 and 43, tab. G. figs. 9–12.

la dent à la loupe, on reconnaît au plus fort du renflement extérieur une ligne circulaire qui indique la limite du capuchon émaillé et de la dentine. La dentine elle-même n'offre rien de remarquable. Les tubes calcifères . . . . . Ceux du sommet se continuent, comme chez le *Polypterus*, dans l'émail, où ils paraissent plus roides, mais en même temps plus fins et moins régulièrement disposés que dans la dentine."

Of *Polypterus* the same author writes as follows:—"Cette dentine forme la plus grande partie de la dent; elle n'est recouverte qu'au sommet par un petit capuchon *d'émail* très-dur, et dans lequel je n'ai pu reconnaître ces fibres composées de petits cubes superposés, telles qu'on les a reconnues chez les mammifères. L'émail du *Polypterus* (fig. 12) est transparent comme du cristal, sans trace de structure, et ce n'est que dans sa base que pénètrent les dernières extrémités effilées des canaux calcifères de la dentine," etc.

Respecting *Saurichthys* it is stated:—"Cette différence entre le socle et le sommet est encore plus frappante, lorsqu'on examine leur structure au microscope; le premier est composé de dentine, le dernier d'émail. La cavité pulpaire est un cône creux entouré d'un cône de dentine massive, sur lequel repose le capuchon émaillé comme dans les dents du Polyptère." This description of the structure of the tooth of *Saurichthys* is very different from that given in the 'Odontography' (page 170), where the cap of enamel is certainly described, but not recognized as such, the author apparently not being aware of the difference between the base and the summit, pointed out by M. Agassiz. And indeed the description seems to be confined to the enamelled or upper portion alone, the basal portion evidently having been deficient in the specimen examined.

Similar passages might be quoted respecting *Lepidosteus*; but perhaps enough has been said on the supposed recent discovery of the "enamel-tipped spear teeth." We have seen that M. Agassiz fully described and accurately figured this form of tooth in four genera (Pl. XVI. figs. 3, 4) between twenty and thirty years ago (1833–1844); and we have determined its existence in four other genera, and have likewise verified the accuracy of M. Agassiz's observations in *Pygopterus*, *Lepidosteus*, and *Saurichthys*, making in all eight in which a cap of enamel is found. It is therefore highly probable that, when the subject is fully investigated, enamel-tipped teeth may prove to be not at all uncommon. But how has all this escaped the observation of the learned author of the 'Odontography'? for escaped him it assuredly has, or he

never could have written as he has recently done respecting *Palæoniscus*, *Amblypterus*, *Pygopterus*, *Polypterus*, and *Lepidosteus*.

Acanthodopsis Wardi, sp., Egerton.

For some time past one of the authors of this paper has had in his collection several jaws of a fish with large triangular teeth, five or six in number, and appearing like processes of the bone; and of so peculiar a character are they that it was impossible to say even to what family of fishes they belonged. It was not until similar specimens were found associated with other remains, that any light could be obtained respecting them. At length a crushed head or two were procured exhibiting the same peculiar jaws with the like curious teeth attached, lying in juxtaposition with the spines of one of the *Acanthodei*, partially buried in what appeared to be the broken-up skin of the fish, crowded with minute rhomboidal scales. In one specimen the two pectoral spines are placed in their proper position behind the head, and united to it by the continuity of tissue, so as to leave no doubt that they and the head belonged to the same fish. The uniting tissue, too, was mainly composed of granule-like scales of a lozenge-form. A tail likewise of an Acanthodian has occurred in the same locality, the scales on which agree both in size and character with those found with the heads. It is therefore quite certain that the jaws alluded to belong to the *Acanthodei*, notwithstanding the abnormal character of the teeth, which in this family are usually described as minute and conical.

In the genus *Acanthodes*, indeed, the teeth appear to have been determined only in one species, though M. Agassiz states, in his description of the genus, that fine teeth disposed in a simple range appear to garnish the circumference of the mouth *. The species in which the teeth have been determined is *A. pusillus*; and of this the same author writes that the mouth is "garnie de très-petites dents qui, même sous une très-forte loupe, ne paraissent que comme des petits points noirs" †. This is so definite that it is impossible to doubt its accuracy; we are therefore forced to the conclusion that in this genus, as at present understood, there are two very distinct kinds of dentition, so distinct, indeed, that it seems necessary to establish a new genus for the reception of those species which, like *A. Wardi*, may have large triangular teeth, similar to those alluded to. We therefore propose the generic appellation of *Acanthodopsis* for those *Acanthodei* with this peculiar dentition.

* Poissons Fossiles du Vieux Grès Rouge, première livraison, p. 39.
† Ibid. p. 36.

The remains in our possession of such fishes are divisible into two species by the characters of the spines, scales, and teeth. One of these is very much larger than the other. It is the smaller of the two that appears to be identical with *A. Wardi*. The larger species is probably the same as that of which Sir P. Egerton had obtained the head and anterior parts, and which is supposed by him to "have measured two feet six inches in length"*. A pectoral spine of this is stated to have been three and a half inches long.

The mandibular ramus of *A. Wardi* (Pl. XV. fig. 6) is about one inch and a half long and a quarter of an inch wide at the broadest part, which is near the proximal extremity, whence it tapers gradually to the distal end, which is rounded; the proximal end turns upwards, and presents a well-defined concave articular surface. The dentigerous bone is very thin, and its walls are usually pressed close together; the outer wall is irregularly striated longitudinally, the inner wall is smooth; the lower margin is strengthened by a stout styliform process, *c*, which is very liable to detach itself, when it assumes the appearance of a cylindrical spine graduating to a point in front; it is united behind to the articular process, and is probably nothing more than a prolongation of the angular bone.

This styliform process has been described as the entire mandibular ramus in some of the *Acanthodei*, and is seen occasionally attached to the head,—the dentigerous bone, with the teeth, having been detached. In Sir P. Egerton's figure of *A. Wardi* these styliform bones, so denuded, are seen still articulated to the head and thrown backwards. The teeth are frequently found attached to the thin-walled dentigerous bone, the styliform process having probably been left so attached to the head.

The teeth are never found separated from the bone. There are five or six in each ramus, two of the larger being in the centre, the smaller ones in front and behind; they are compressed in the direction of the jaw, and when seen in this position they have the shape of as many equilateral triangles with the lateral margins a little hollowed towards the apices, which are recurved; they are expanded at the base, where they become confluent, and are coarsely and irregularly striated from one extremity to the other; and the surface being liable to erosion, the striation is frequently exaggerated.

The upper jaw is coextensive with the mandible, and is apparently formed of one piece. The teeth are like those of the under jaw, and lock very accurately into them; they are of

* Quart. Journ. Geol. Soc. vol. xxii. p. 470.

the same size and character, and are equal in number to those of the mandible. The largest teeth are nearly one-sixth of an inch in length; they are much wider than they are thick from back to front.

On making a longitudinal section of the teeth in the direction of the jaw, the structure is found to be very peculiar. The jaw itself is composed of very dense bone on the surface, in which the Haversian canals are well defined, and the radiating cells are very numerous and minute; they are elongated-fusiform, with the canaliculi (when observable) sufficiently abundant and arranged for the most part at right angles to the long axis of the cells. In the superficial and denser portions of the tissue the cells and tubules are the most minute; in the deeper portions they are larger and less regular in form, and the bone becomes riddled with medullary cavities, until at length it is entirely reduced to a sort of cellular structure. This curious cellular tissue is continued into the teeth, and forms their central mass, there being apparently no distinct pulp-cavity, or, if any, it is confined to the base. This tissue becomes less open as it approaches, and gradually forms a dense layer at, the surface of the teeth, in which layer the Haversian canals are as distinct as they are in the bone of the ramus, and the cells, diminished in size, assume their regular elongated form, and at the extreme margin they disappear. This peripheral layer, which represents the dentinal wall of ordinary teeth, is found to be continuous from tooth to tooth; it differs, however, in no respect from the dense external surface of the ramus. Indeed it is quite evident that the bone of the jaw is continued into and forms the teeth; they may therefore be looked upon as processes of the jaw. We have failed to detect the least trace of enamel on the surface of the teeth.

A considerable portion of one of the pectoral spines lies near to the crushed head of this species, in which the jaws are distinctly displayed with the teeth interlocked. The spine has lost its distal extremity; the fragment, however, is flattened towards this end; at the basal extremity it is thickened, and assumes a triangular form; a groove extends along the anterior margin. Detached spines have also occurred, agreeing exactly with Sir P. Egerton's description of the pectoral spine of this species.

The scales are minute rhombs, with the upper surface smooth and slightly convex. Some appear to be minutely and irregularly granulated. Perfectly similar scales clothe the heterocercal tail which was procured at Newsham, and which we believe to belong to this fish. It is about three-

quarters of an inch wide, and, including the pedicle to which it is attached, it is one inch and three-quarters long; the under lobe is not much produced, and the upper is rather obtuse; no rays are perceptible. The scales are well preserved, and are in an undisturbed state. Some of them are brilliantly glossy, and have towards the posterior angle a boss-like swelling; others are dull and minutely granular. Which is the true natural surface it is difficult to say, though it seems probable that the latter is. Be this as it may, both kinds of scales are found scattered in the vicinity of the head and spine.

Acanthodopsis Egertoni, n. sp.

A crushed head with the pectoral spines attached, a detached jaw or two, a few separate spines, and some scattered scales are all the remains that have occurred of the large species alluded to. The head, which could not have been less than two and one-quarter inches long, has one of the mandibular rami well displayed, with the teeth attached; but they are, unfortunately, in a very imperfect state. The ramus is very similar in character to that of *A. Wardi*; but the dentigerous bone does not appear to be striated; the styliform process is not much arcuated at the proximal extremity, and tapers gradually to the anterior point. The teeth are arranged in the same manner as in the smaller species—that is, with the larger in the centre and smaller at the extremities of the jaw; with the aid of a detached mandible we are able to ascertain that there are seven or eight in each ramus; they are not nearly so wide at the base as in the previous species, and they are more regularly and finely striated. Some of the bones of the head are finely and regularly tuberculated; these are probably the orbital plates. The similar plates of the other species appear to be irregularly granular.

The spines attached to the head are upwards of two and a half inches long, though they are not entire; but the largest detached specimen in our possession is quite an inch longer, though in it, too, the point is broken. This must have been longer than the largest mentioned by Sir P. Egerton; it is upwards of one-quarter of an inch broad, and is flat and curved like the others, resembling the blade of a scimitar; towards the base the inner margin is thickened and angulated, and a depressed line or groove extends from end to end a little within the anterior or arched margin; a few fine longitudinal lines are seen near to and almost parallel with the opposite margin; the point appears to be rounded, but is not quite perfect in any of our specimens.

The scales which are found associated with the head and

spines are very similar to, but they seem to be smaller than, those of the other species, as pointed out by Sir P. Egerton; they also appear to have the surface more elevated and rounded.

From the character of the scales and great size of the pectoral spines, but more particularly from the difference observed in the teeth, we consider ourselves justified in dividing this from the *A. Wardi*, and beg to dedicate it to Sir P. Egerton, who was the first to point out the probability of its specific distinctness. We therefore propose for it the name of *Acanthodopsis Egertoni*.

Gyracanthus tuberculatus, Agassiz.

The gigantic spines of this little-understood fish occur pretty frequently at Newsham and Cramlington in a fine state of preservation. In conjunction with Mr. J. W. Kirkby, one of the authors of this paper pointed out in 1863 that these spines were not, as usually thought, dorsal, but were paired spines, most probably pectoral *. We have now before us seventy-one of these formidable weapons; and the first thing that strikes the observer is, that by far the greater number have lost the apical extremity, and that they are not merely bent from front to back, but are also laterally curved. On closer examination it is found that there are as many bent to the right as to the left side, and that of such bent spines there are just twenty-four pairs. Thus twenty-three spines are left unaccounted for; these may be considered straight, being bent only from front to back, and their points are entire. But first respecting the paired spines: we have said that they have all lost their points; they are not fractured, however, but are all worn smoothly down diagonally at a very acute angle; and, what is still more interesting, this wearing always takes place at the side opposite to that of attachment. Assuming, therefore, that these spines are pectoral, and that they were inclined backwards and downwards, as assuredly they would be, then the wearing of the points is exactly such as would take place by their coming in contact with the ground. And, again, the largest or oldest spines are uniformly the most worn; some, indeed, are reduced to mere stumps. In one such specimen now before us, which is seven inches in circumference, and which must have been one of the very largest, only ten and a half inches are left. Another example, six inches in circum-

* See paper entitled "Fish-Remains in the Coal-measures of Durham and Northumberland," by Messrs. T. Atthey and J. W. Kirkby, read in the Geological Section at the Newcastle Meeting of the British Association.

ference, is only seven inches long, including the portion buried beneath the skin.

All this seems to demonstrate, beyond doubt, that these are really paired spines, most probably pectoral; and from this wearing we may fairly assume that *Gyracanthus* was a ground-fish, and that the spines assisted its motions at the bottom of the water.

The straight spines, or those which are not laterally bent, are all regularly arched from before backwards; and their distal or pointed extremities are all perfect, not being in the least degree worn. These are apparently dorsal spines; and that there is only one of such in each fish seems probable from the fact that they occur in the ratio of one to two of the paired spines, as shown by our previous division of the seventy-one specimens.

The dorsal spines are considerably smaller than the paired ones; they are more compressed, and the posterior denticulated keel is more strongly developed; the extreme point is smooth, compressed, and rounded in front. The largest are about eleven inches long, and three and one-quarter inches in circumference at the thickest part. The paired spines are fifteen or sixteen inches in length, and upwards of six and a half inches in circumference.

One or two specimens of the species denominated *G. formosus* have likewise occurred; and as the same spine of *G. tuberculatus* is occasionally found with both tuberculated and smooth ridges, the former can scarcely be considered a good species. M. Agassiz's figure of *G. formosus* *, like *G. tuberculatus*, is laterally bent.

Large flat triangular bones are frequently found associated with the spines, measuring sometimes eight and a half inches long and six and a half inches broad at the widest part. Their structure is very open; and as they are seldom well preserved, they are probably only imperfectly ossified; the bone-fibre radiates from the apex to the expanded base. There can be little doubt that these are carpal bones, similar to those in connexion with the pectoral fins in the Sharks and Dogfishes. This bone is thickest at the apex, which is rounded, and thins out towards the distal expanded margin or base. The large longitudinal groove at the root of the spine probably corresponds to the lower or anterior margin of this bone; or it may be that it was fitted to a lower carpal which was coadjusted to this bone but, being entirely cartilaginous, has disappeared. However this may be, it can scarcely be doubted that this

* Poissons Fossiles, vol. iii. tab. 5. figs. 4, 5, 6.

triangular bone supported, directly or indirectly, the great pectoral spines.

There are found also frequently associated with the remains of *Gyracanthus* large thin layers or patches of matter, almost entirely composed of minute compressed bodies, of which there are two kinds. One, much smaller than the other, and by far the more numerous, is upwards of one-twentieth of an inch high and not quite so broad; it has usually two, sometimes three, conical, recurved, diverging points rising from an expanded base. The large kind is usually one-tenth of an inch high, and is somewhat wider at the base; it is sometimes a little larger, but more frequently much smaller. It is much compressed, and the base is considerably widened; the upper margin is divided into from four to seven much recurved conical denticles, which are sharp-pointed, and have four or five stout longitudinal ridges on the arched or dorsal surface. Several large patches of these bodies have occurred, one of which measures twenty inches by fifteen inches. It is therefore pretty clear that they cannot be teeth, which are not usually found together in such vast multitudes; they are much more likely to be dermal tubercles, and these patches to be the remains of the skin of *Gyracanthus*. It should also be mentioned that *Cladodus mirabilis* has occurred three or four times at Newsham, and always associated with these dermal patches. May it not, therefore, prove to be the tooth of *Gyracanthus*?

Note.—*Mitrodus quadricornis* of Prof. Owen (pl. 3) is undoubtedly nothing more than the larger kind of these dermal tubercles. In size, proportion, and form it agrees exactly with them; and in the minute structure there is no difference whatever, as is demonstrated by the numerous sections of them which we have had the advantage of examining. This "minnow," then, of our shales is found to be identical with *Gyracanthus tuberculatus*, perhaps the largest fish of the coal-measures.

In the figure of *Mitrodus* only a small portion of the denticles is shown; the points, being strongly recurved, are necessarily cut away in such a section as that represented. It is only the base of the toothlets that Prof. Owen has seen; and consequently his knowledge of the true form must be very imperfect. The angles represented at the margin of the denticles indicate the external ridges described above.

Diplodus gibbosus, Agassiz.

This is a common fossil at Newsham and Cramlington, and is usually found in connexion with a thick granular layer of

a substance resembling shagreen, large patches of which frequently occur studded all over with it. One such patch has been obtained which measured fifteen inches long and about seven inches wide. On this the *Diplodi* are comparatively few in number, and are scattered about. But in another patch, of which there are fifty-six square inches, they are very numerous, and are crowded together without order.

There can be little doubt that these shagreen-like patches are the remains of the skin of some large fish, and that the *Diplodi* are dermal tubercles in connexion with it, analogous to the spinous tubercles of the Rays. At the same time it must be admitted that it is possible enough that the larger specimens may have clothed the lips or jaws with a spinous pavement resembling in arrangement the oral armature of the Rays or Cestracionts; or they may have ranged along the back or sides of the body in serial order, as the dermal spines frequently do in the Rays; or perhaps they may have been scattered here and there among the smaller ones, as is not unfrequently the case with such tubercles.

Diplodus has usually three recurved spines, two being large, the third quite small; they stand up from a common, rather deep, rounded or oval base. The two large or lateral spines are ranged side by side; they are stout, conical, and divergent, both being curved from before backwards, and a little compressed in the same direction. The small spine is similar in form, and is placed immediately behind the large ones, at their basal junction; and in front of them, in a similar position, there is a large, rounded, depressed tubercle. All the spines are strongly carinated at the sides from the apex to the base; and in well-developed specimens there are two other ridges, one in front, the other behind, extending downwards for some distance from the apex.

These are the normal characters of *Diplodus*; but it is very variable in form. The spines are not unfrequently found stiff and short, and much bent and divergent; on the other hand, they often occur much elongated, almost parallel, and comparatively slender. The number of spines also varies; sometimes there are only two, sometimes only one. When the latter is the case, the specimen is usually exposed in profile, and the long heel-like projection is well displayed; when, however, a complete tubercle is buried in the matrix with only one of the lateral spines and its base exposed, the appearance is much the same. A tubercle so seen is represented by M. Agassiz in 'Poissons Fossiles,' vol. iii. tab. 22 *b*. fig. 5.

If *Diplodus* differs much in form, it also varies greatly in

size. The largest are three-quarters of an inch from the base to the apex of the large or lateral spines; the smallest, measured in the same way, are not more than one-twelfth of an inch in extent. Between the two extremes, tubercles of every size occur. Now the smaller individuals, which are by far the most numerous, agree very well with *Diplodus minutus* of Agassiz, so far as the imperfect specimens described and figured by that author permit a comparison. M. Agassiz says he was not able to discern the median cone; but this is not to be wondered at, for none of his figures represents the base entire.

Note.—Dittodus divergens, *Aganodus apicalis*, *Aganodus undatus*, *Pternodus productus*, and *Ochlodus crassus*, described in the paper "On the new Coal Fishlets," are all referable to *Diplodus*. The genus *Dittodus* is established on two very dissimilar fossils: *D. parallelus* is, we have already seen, founded on the fragment of a jaw with a few of the teeth of *Rhizodopsis sauroides; Dittodus divergens* (pl. 2) is apparently nothing more than *Diplodus minutus* * of Agassiz; and, like his figure, that given by Prof. Owen is represented without the small central spine: indeed it is scarcely possible to show it in such a section as that figured in plate 2. The size, form, and histological characters all agree with those of our sections of the minute specimens of *Diplodus*.

Pternodus productus (pl. 10) is the single-spined variety of *Diplodus gibbosus* seen in profile, with a well-produced base; or it may possibly be a lateral section of a fully developed specimen in which one of the large spines only is exhibited. In either case the same appearance would be presented of the large projecting "heel," with its outline sweeping into the curve of the spine; and, in fact, the form, proportions, and size all exactly agree with those of similar sections in our possession of the single-spined variety of *Diplodus*. The minute structure is precisely the same; the greater portion, however, of the basal marginal boundary, from *m* to *b* in fig. 1, pl. 10, has been ground away; and that which is designated "osseous tissue of jaw" is merely a portion of the osteo-dentine of the pulp-cavity.

There are two species of *Aganodus* described: one, *A. apicalis* (pl. 9), is based apparently on a section made from before backwards of a single straight spine of the small variety of *Diplodus*. The two processes (*o*) below the spine are projecting portions of the base, the most of the base itself having been broken away. The opening between the two processes

* Poissons Fossiles, vol. iii. p. 205, tab. 22. f. 6–8.

is in part a natural cavity, frequently seen in sections. *A. undatus* (pl. 10) is a lateral section of a single minute spine of the same variety of *Diplodus*, somewhat abnormal in form. There is no difference of importance in the minute structure, and it exhibits in a most distinct manner the numerous concentric layers of dentine mentioned by M. Agassiz as characteristic of *Diplodus* (vol. iii. p. 209).

Diplodus has supplied Prof. Owen with still another generic form, which is the fourth based upon this variable fossil. *Ochlodus* (pl. 5) is nothing more than one of the large varieties of this dermal tubercle, crushed laterally—a variety, probably, having originally one of the large spines smaller than the other. A figure of such a tubercle is given by Mr. Binney in the paper before quoted *. From the representation of *Ochlodus* it is evident that the specimen has been crushed: the dentinal walls are cracked in several places, the upper wall has been forced in upon the osteo-dentine of the pulp-cavity, and the continuity of the tissue of the spines has been severed; the osteo-dentine of the pulp-cavity has, in a great measure, been displaced, and the base shattered to fragments. All these appearances are shown in a section now before us, which was made of a specimen crushed laterally or a little diagonally, and which closely resembles in size and contour *Ochlodus*. It is evident, too, that much of the fractured base in this genus, and also a considerable portion of the two smaller spines, have been removed in making the section.

The thickness of the dentine and the size of the pulp-cavity are very variable features in *Diplodus*. Even in the same specimen the peripheral dentine occasionally varies considerably at different parts of the circumference, as may be seen on making a transverse section of the spines; and as they are compressed, as we have stated above, the relative size of the pulp-cavity varies with the plane of the section. This is one source of variation; but were the pulp-cavity quite cylindrical, or rather circular in transverse section, its apparent relative proportion to the dentinal wall would depend upon the degree of eccentricity of the section. The pulp-cavity is consequently found to vary extremely in size in *Diplodus*. In the crushed specimen we have spoken of, this cavity is quite as large as it is represented in the figure of *Ochlodus*; and, again, in other specimens it is no larger than we see it in the figure of the so-called *Pternodus productus*.

The acute points represented in the section of *Ochlodus* are not the apices of the spines as believed by Prof. Owen; the true apices have all been removed in making the section

* Trans. of the Manchester Geol. Soc. vol. i. pl. 5. fig. 17.

These sharp prolongations are merely the ridges or keels described above as extending from the apices downwards, seen still projecting after their base (the dentinal support) has been removed. The same appearance is presented at the apex of the figure of *Aganodus undatus*, and strengthens our opinion of the nature of that form.

At the point of the largest spine of *Ochlodus* there is evidence of two of those ridges or keels, one probably being a lateral ridge, the other apparently the intermediate or dorsal one. At the extremity of the small lateral spine, one of the strong lateral keels is well exhibited; and the small central spine displays distinct evidence of two keels. In many of our sections these ridges assume the very same appearance which we see in this figure; and they are all found to be composed of enamel, as these points are represented to be in *Ochlodus*; and there can be no doubt that the trace of enamel described and indicated at *g*, on the large spine, is a lateral view of the keel the lower point of which terminates at *g*.

We thus find that *Ochlodus* does not only agree in general form, but even in the minutest details, with *Diplodus*; and we can find no distinguishing histological characters on which to found this so-called genus.

Ctenoptychius pectinatus, Agassiz.

This species is not uncommon in the shales at Newsham and Cramlington. One of the authors of this paper has a large suite of specimens gathered at these localities; they agree perfectly well with *C. pectinatus*, though they usually have a greater number of denticles than represented in the figure in 'Poissons Fossiles.' The number ranges from eight or nine to fifteen or sixteen. Well developed specimens measure one-quarter of an inch wide and a little less high. They are in the form of wide, flattened plates, with the upper margin a little arched transversely and denticulated, the denticles being rather obtusely pointed, compressed from before backwards, and recurved; the marginal surface is concave behind and convex in front, and thickened posteriorly, where it is strongly defined from the base by a deep transverse constriction. A lateral section consequently presents a sigmoid curve, the lower member of which is the larger and less bent. The whole of the denticulated margin, including the denticles, is coated with a thin layer of enamel, only traces of which can usually be seen in sections. The base narrows suddenly immediately below the denticulated margin, and is frequently considerably longer than the upper glazed or enamelled por-

tion; and the lower margin is often produced into two or more fang-like processes.

In the base of each denticle there is a small pulp-cavity that extends only a short way upwards, and is in direct communication with the wide medullary canals of the basal portion, which are for the most part elongated; but in this respect there is considerable variation. The canals are most elongated, as might be expected, in elongated specimens. The dentinal tubules, which are nearly vertical, are coarse, fasciculated, and much branched; and the osteo-dentine of the base exhibits also a few branched tubules, strongest and most numerous above and at the margins; below they are comparatively small and obscure.

A few specimens have occurred which are much elongated transversely, and have upwards of twenty denticles; these are probably *C. denticulatus* of Agassiz. *Ctenoptychius* is probably a dermal tubercle, though it certainly has more the appearance of a tooth than either *Diplodus* or the spined dermal tubercles which have been assigned to *Gyracanthus*.

Note.—That *Ageleodus diadema* of Prof. Owen (pl. 4) is the fossil above described cannot for a moment be doubted. In general form, size, number and character of the denticles, as seen in section, all exactly agree; and there is no difference whatever in the histological features: only the specimen figured and described in the paper referred to is shorter than usual; hence the medullary canals are not so decidedly elongated as they frequently are. Now no palæontologist would hesitate to pronounce our specimens to be *Ctenoptychius pectinatus* of Agassiz. It is therefore futile to assert that the figure of the structure of this genus in the 'Poissons Fossiles'* shows "at a glance" that it is generically distinct from *Ageleodus*; and it is certainly erroneous; the difference is merely a difference in degree. The medullary canals are more elongated and somewhat more regularly parallel in Agassiz's figure than they are in our specimens, in many of which, however, the parallel and elongated character predominates. In fact there is quite as great a difference in this respect between individuals of our suite of specimens as there is between some of them and Agassiz's figure referred to. And it must not be forgotten that this figure represents the structure in a different species. We repeat, then, that no generic difference is perceptible at a glance. M. Agassiz certainly states that the substance at the base of the tooth is perfectly homogeneous. In some of our specimens, too, the basal portion has lost nearly all traces of

* Tome iii. pl. M. figs. 4, 5.

structure; but such specimens are mounted in balsam, which, we have seen, is liable to render minute structure invisible. It is therefore not improbable that the specimens of M. Agassiz may have been mounted in this medium; and it is equally likely that the minute structure was not preserved in the fossil examined by him. Such discrepancies must be expected in the examination of *fossils*; and accordingly we have already seen that the minute structure in *Ctenodus* had escaped the observation of that naturalist.

In *Ageleodus* we see another striking instance of the danger of trusting entirely to the sections of objects not previously understood. From this cause the denticles are described as if their whole contour was seen, whereas there is nothing but the mere stumps left in the section, the crowns all having been cut away in making it. As the denticles are (as we have already stated) recurved, they must necessarily, to a great extent, be removed in such a section as that figured. Had this been previously known, the bases of the denticles could never have been mistaken for their crowns, nor could the latter have ever been described as "broader than they are high;" nor could it have been stated that they all "terminate obtusely; and this seems to be an original form, not due to wear or abrasion." In fact, Prof. Owen describes merely a diagonal section of the basal portion, and supposes that he describes the whole denticle. This author has likewise been deceived into the belief of the existence of a common pulp-cavity, by the removal in the section of the osteo-dentine near the centre of the specimen. Here all the substance has been ground away in consequence of the lateral sigmoid bend before described. A lateral section proves that no such cavity exists; and, indeed, the large series of sections now before us, and which were made many years ago, entirely disprove this assertion. The inference drawn from the supposed presence of this cavity is therefore of no avail.

We have now examined the whole of the new genera and species of Fishes and Batrachians proposed by Prof. Owen in his paper published in the 'Transactions of the Odontological Society," and find ourselves compelled to conclude that there is positively not a single novelty in the whole series. Thirteen genera were enumerated in the "Abstract" of the paper as read; in the paper as published there are only twelve, one (entitled "*Oreodus*") having been withdrawn. It is unfortunate that some circumspection had not been also observed with regard to the remaining twelve, which, we fear, are fated to fall into the like obscurity. We have found as we approached the "New Coal Fishlets" that they gradually

dwindled away, and at length entirely disappeared; or rather we perceived that they never had had any real existence, and that the "Minnows and Sticklebacks" of the Northumberland coal-shales have yet to be discovered.

EXPLANATION OF THE PLATES.

Plate XIV.

Fig. 1. Sternal plates of *Pteroplax cornuta*, about half the natural size: *a a*, lateral plates; *b*, posterior portion of central plate appearing from beneath the former; *c*, posterior process.

Fig. 2. View of underside of central sternal plate, two-thirds natural size: *a*, perfect lateral wing or lobe; *b*, posterior process.

Fig. 3. Præmaxilla of *Pteroplax cornuta*, natural size, the apices of the teeth having been restored: *a*, anterior extremity; *b*, posterior articular process; *c c*, mucus-grooves; *d*, external nostril.

Plate XV.

Fig. 1. Cranial shield of *Pteroplax cornuta*, about two-thirds natural size: *a*, frontals; *b*, parietals; *c*, occipitals; *d*, postfrontals; *e*, epiotics; *f*, parietal foramen; *g*, posterior horns; *h*, inner posterior orbital border.

Fig. 2. Front view of vertebra, three-fourths natural size: *a*, centrum, showing a minute notochordal foramen in the centre; *b*, neural canal; *c*, spinous process, restored from another specimen; *d*, transverse process; *e*, anterior zygapophysis.

Fig. 3. Inside view of mandibular ramus of *Palæoniscus*, showing the row of laniary teeth almost perfect, but turned by pressure so as to present their sides; the row of small exterior teeth is buried in the matrix: *a*, anterior extremity; *b*, posterior articular process; *c*, impressions of the surface-striæ in the matrix, a portion of the bone having been removed.

Fig. 4. External view of a maxilla of another species of *Palæoniscus*, exhibiting both rows of teeth, the laniary and the small exterior teeth appearing to be in the same line, on account of pressure: *a*, anterior extremity; *b*, tooth figured in next plate.

Fig. 5. Inside view of a portion of the alveolar border of the jaw of *Palæoniscus*, showing the row of laniary teeth within the small exterior row: *a*, laniary teeth; *b*, impressions in the matrix of the teeth of the exterior row; *c c*, three of the small exterior teeth left adhering to the matrix.

Fig. 6. External view of a mandibular ramus of *Acanthodopsis Wardi*: *a*, anterior extremity; *b*, posterior extremity; *c*, styliform process attached to the dentigerous bone, *d*.

Plate XVI.

Fig. 1. Tooth from maxilla of *Palæoniscus* (Pl. XV. fig. 4 *b*): *a*, enamel-tip.

Fig. 2. Section of tooth of *Palæoniscus*, exhibiting the cap of enamel, *a*; *b*, film of enamel coating the crown, very frequently absent.

Fig. 3. Section of tooth of *Pygopterus*, from Agassiz, showing the enamel-tip, *a*.

Fig. 4. Section of the upper portion of the tooth of *Polypterus*, from Agassiz, showing the cap of enamel, *a*.

Fig. 5. Section of portion of maxilla of *Rhizodopsis*, much enlarged, exhibiting the bony pillars supporting the teeth: *a a*, bony pillars; *b*, *b*, teeth in an abraded condition, the enamel having all disappeared, and, in some instances, portions of the dentine.

XLVI.—*On the Development of the Position of the Eyes in* Pleuronectidæ. By Prof. J. C. Schiödte. Communicated by C. A. Gosch, Esq.

[The question of the asymmetry of Pleuronectidæ has of late attracted so much attention, and we possess so few reliable descriptions of the appearances presented by very young specimens (whereby alone that question can be solved), that the following observations on this subject by Prof. Schiödte will doubtless be found highly interesting, not only to ichthyologists, but to zoologists generally. I wish particularly to draw attention to two of his results, now established by actual examination of successive stages of development of the same species, viz.:—first, that the eye of the blind side glides across the head in front of the dorsal fin without ever disappearing from view, and, when arrived on the other side of the dorsal fin and clear of it, recedes backward alongside the fin, which does not, as supposed by some, prolong itself after the passage of the eye; and, secondly, that this shifting of place is a very slow process, for which, in all probability, preparation is made in the fœtus.

Prof. Schiödte's article is destined shortly to appear in the fifth volume of the 'Naturhistorisk Tidsskrift;' but having been favoured by the author with a separate impression, I am enabled already to present it to the readers of the 'Annals.' The author begins by describing the specimens which form the principal material of his treatise in the following manner.]

On examining a young specimen of *Rhombus barbatus* which lies before me, and which measures 18 millims. in length from the apex of the closed lower jaw to the extreme end of the caudal fin, I observe that the ramifications of the mucuparous canal on the head are not traceable; but the outline of the parts of the mouth, of the præoperculum, and the opercula are clearly perceptible through the skin, as well as the layers of the muscles, particularly of the great masseter on the right side. The left eye stands very nearly opposite to the middle of the upper jawbone. The right eye is placed at the top of the head, in front of the dorsal fin, but so much inclined to the left, that only one-third of its surface is visible when the fish